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Nr. 9. Johs. Schmidt: ON THE POST-LARVAL STAGES OF THE JOHN DORY (*ZEUS FABER* L.) AND SOME OTHER ACANTHOPTERYGIAN FISHES. WITH ONE PLATE

KØBENHAVN
I KOMMISSION HOS C. A. REITZEL
BIANCO LUNOS BOGTRYKKERI
1908

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BY

JOHS. SCHMIDT

WITH ONE PLATE

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CONTENTS

page

A. John Dory *(Zeus faber)* and Boar-fish *(Capros aper)*:

1. John Dory (*Zeus faber*, Linné) 3
   Description of the developmental history 3
2. Boar-fish (*Capros aper*, Lacep.) 5
   Verification of the determinations 6

B. The Common Pogge *(Agonus cataphractus)* and the Arctic Pogge *(Agonus decagonus)*:

1. The Arctic Pogge (*Agonus decagonus*, Bloch, Schneider) 7
   Description of the developmental history 7
2. The Common Pogge (*Agonus cataphractus*, L.) 10
   Verification of the determinations 10
   Remarks on the occurrence of the two species of Pogge within the regions investigated by the "Thor" 11

Explanation of Plate 12

A. THE JOHN DORY (*ZEUS FABER*) AND THE BOAR-FISH (*CAPROS APER*)

1. John Dory (*Zeus faber* Linné)

So far as I am aware, nothing is known regarding the early developmental history of the Dory beyond what is given by E. W. L. Holt (in "Annales du Musée d'histoire naturelle de Marseille", vol. V, 2, p. 21, Pl. III, fig. 28, 1899) concerning some pelagic eggs taken in 1899 in the Mediterranean and the larvæ hatched from these, which were referred to *Zeus faber*.

The pelagic, postlarval stages described and figured here were taken by me (on the "Thor") from the end of August to the middle of September 1906 in the English Channel and in the mouth of this as also S. W. of Brittany, all over moderate depths, within 200 meters — almost all indeed within the 100-meter curve. We thus see that the John Dory must spawn in these waters and that the spawning must take place in summer[1], which I conclude from the fact that I did not find the young either in April—May 1906 or June 1905, when the "Thor" earlier visited these waters, but only at the end of August and in the middle of September.

That the Dory should spawn so late as summer here in the neighbourhood of the northern boundary of its spawning region is for the rest in good agreement with its southerly distribution, as it seems to be a general rule that in waters where forms of more southerly distribution meet with forms of more northerly distribution, the former chiefly spawn in summer, the latter in winter.

I shall give here with the aid of the figures on the Plate a brief description of the postlarval developmental history of the John Dory so far as this is shown by the available material, which however does not contain quite the youngest postlarval stages, as the smallest specimens to hand measure already ca. $7^3/_4$ mm.

Description of the developmental history

Length: $7^3/_4$ mm. In spite of its small size this stage is already far forward in development, the form of the body being for example very high and compressed. Thus, the maximum height is 3·7 mm. and the distance from the tip of the snout to the caudal fin 6 mm. Its superficial appearance is that of a parallelogram, the front line of this being formed by the part from the tip of the snout to the back of the head, the posterior line by the part from the ventral fins to the caudal fin (see figure). As will be seen, this parallelogrammic form alters during development. In these youngest stages examined the upper and lower margins are considerably longer than the anterior and posterior, and the highest point of the trunk lies in front of the dorsal fin. It is also characteristic that the hind part of the dorsal contour (behind D^1) is somewhat concave, which applies also in part to the corresponding portion of the ventral Pl. I, fig. 1

[1] see also Ehrenbaum: Nordisches Plankton, 4. Lieferung, I, p. 124, 1905, where the literature is given.

contour; both conditions alter during development. The snout is very short and its angle very obtuse, larger than 90°. The opening of the mouth is very large. The eye, which is still in an early stage (the circumference not completed) is of very considerable size. In contrast to the condition in *Capros aper* it is placed very far forward, quite close to the front of the head.

The tip of the notochord is much bent upwards, but still very strong, and its free end almost half as long as the longest rays in the caudal fin. In the latter about 10 rays are formed, the uppermost and lowermost of which however are still not very distinct. The tail is heterocercal and all the rays hypural. The posterior margin of the part from which they spring is already almost vertical. The unpaired fins are already distinctly formed, in spite of the small size of the fish; thus the caudal fin is almost quite separated from the anal and 2nd dorsal. There still remains, however, a considerable portion of the embryonic fin in the upper part of the caudal fin. This portion, in which rays are quite lacking and in the middle of which lies the free end of the notochord, disappears completely later. In D^1 (or rather the spinous portion of the dorsal fin) there are ca. 5 distinct rays. There are also fairly distinct indications of rays in D^2 and A, ca. 15 in each, but the anterior, spinous portion of the anal fin is as yet not formed. The ventral fins are elongated, broad and hand-shaped. They contain 6 rays, the 3rd of which is the longest, namely about $2^1/_2$ mm., the 5th and especially 6th the shortest. They reach posteriorly almost to the middle of the anal fin region. The pectorals are fan-shaped lobes. The whole surface of the body is densely beset with small, stellate chromatophores with larger intermixed. There is also pigment on the distal and anterior portion of D^1 and over the whole of the ventral fins. On the other hand, pigment is quite lacking on the remaining fins. The strongest pigment is that on the ventral fins which therefore appear very dark.

Pl. I, fig. 2 **Length: $8^1/_3$ mm.** The occipital region is still extremely arched and prominent. The highest point of the trunk lies far forward, in front of D^1. The upper and lower sides of the parallelogram formed by the contours of the fish are thus still longer than the anterior and posterior. Posteriorly, the body is now somewhat higher than before, the contours opposite D^2 and A not being so concave as previously. The greatest height is quite $4^1/_4$ mm. and the distance from the tip of the snout to the beginning of the caudal fin ca. $7^1/_2$ mm. The free end of the notochord is somewhat reduced in size. The rayless, upper portion of the caudal fin has not yet disappeared, though it is less than in the previous stage. The fins are naturally somewhat further forward in development than before. The caudal fin had ca. 12 rays. In D^1 there were ca. 9, the hindmost weak. This fin begins to be lobed or toothed at the margin, the parts between the rays being lower. D^2 showed ca. 15 moderately distinct rays, but in the posterior portion they are not yet differentiated. In the anal fin the first low (spinous rayed) part is now marked off, but its rays are still not distinct; in the non-spinous part of the fin ca. 21 rays were counted. In the ventral fins there were 6 distinct rays and a faint indication of a 7th, whilst the 3rd ray was long. They have otherwise essentially the same broad, hand-shaped appearance as previously. The pigmentation is in the main as before, and of the fins only D^1 and the ventral fins have pigment. As the figure shows, however, there are already indications of the characteristic, undulating pigment lines on the lateral aspects which later become very distinct.

Pl. I, fig. 3 **Length: $10^1/_2$ mm.** The greatest height is 5·6 mm. and the distance from the snout to the beginning of the caudal fin 7·7 mm. The form is shorter than before and the highest (uppermost) point of the body has moved somewhat backwards, so that it is now placed at the beginning of D^1. The form has thus begun to resemble the later appearance though it is still far from this and the part between D^1 and the head is still much more arched than in the older stages. An increase in height of the posterior portion of the body also contributes to make this stage begin to resemble the later form, as the contours opposite D^2 and A are now convex.

The tip of the notochord is greatly reduced and lies in the upper margin of the caudal fin, the rayless upper part of this (remains of the embryonic fin) having now disappeared. The caudal fin contains 13 distinct rays, i. e. the full number, and this also applies to the other fins. D^1 had 9—10 rays, 7 of which were stronger, and D^2 ca. 23, all fairly distinct. In the anal 4 + 22-23 rays were counted, as in the front, lower portion of the fin the 4 spinous rays are now formed. The ventral fin had 7 rays, the middle ones the longest and the hindmost the shortest.

With regard to pigment, it may first be mentioned that D^1 has also pigment now in its proximal part but it is strongest distally. On D^2 and A there is a small pigment-group almost in the middle of the fin, on the interspinous bones, which extends out a little on to the fin itself. There is a little pigment also on the low, anterior spinous portion of the anal fin. The ventrals are still strongly pigmented, but otherwise the fins lack pigment.

The undulating lines of pigment on the body, already mentioned under the preceding stage, are now much more distinct. As specially prominent may be mentioned, the two which run almost parallel with the longitudinal axis on each side of this to opposite the middle of D^2 and A, as also a curved line between D^1 and the pectoral fins. Further reference may be made to the figure.

Length: 19 mm. The greatest height is 10 mm. and the distance from the snout to the caudal fin ca. 14 mm. The fish has now almost the form of a broad, rhombic plate and its uppermost point lies opposite D^1. The region between D^1 and the head is no longer so strongly arched and the form is now on the whole more like that of the adult fish; the height is however relatively greater. The posterior portion of the body has especially increased in height and its contour opposite D^2 and A is now evenly convex. Pl. I, fig. 4

The end of the notochord is now quite reduced. The number of caudal rays is 13 and the fin has a length of ca. 5 mm. with the upper and lower borders almost straight, whilst the posterior is arched-convex. In D^1 there were 10 rays with the 4th and 5th the longest. Its margin is distinctly incised, finger-like. D^2 had 24 rays and the interspinous bones, as in A, are beset with a small number of large warts (the beginnings of the bony plates), which are most distinct in front. The anal fin contained 4 + 22 rays and the ventrals 7 with the middle ones the longest. The fins have now in the main their final form (excepting the skin prolongations on D^1) and the full number of rays is present.

The pigment shows a further development of the wavy lines already described, which can be much more easily seen from the figure than described. Further, the characteristic dark spot centrally on the fish, which distinguishes the John Dory, has now begun to form. On the fins pigment is absent on the caudal as also D^2 and the greater part of the anal. On the interspinous rays of D^2, in addition to the central pigment group already present in the preceding stage, we now find a second in front of this, and the same is the case with the soft-rayed portion of the anal fin. The low spinous-rayed portion of the latter is now strongly pigmented as also D^1, where the most marked pigment has now collected into a cross-band almost medially on the fin. The ventral fins are still well-pigmented and here also the pigment shows signs of collecting into transverse bands.

2. Boar-fish (*Capros aper* Lacep.)

From Cunningham[1] and Holt's[2] investigations in the English Channel we know the very earliest developmental stages of this species, which belongs more especially to the Mediterranean, but as acquaintance with the postlarval stages is still lacking I may describe here a specimen taken by the "Thor" in the middle of September 1906 in the western part of the Channel. The period at which it was found

[1] Cunningham (Journ. Mar. Biol. Assoc., N. S., vol. I, p. 10, Pl. I, figs. 1—2).
[2] Holt (Annales du Musée d'Historie Naturelle de Marseille, tome V, 2, p. 26, Pl. V, figs. 43—48).

confirms the spawning time given by the above authors for the boar-fish in the English Channel, namely, June—August, and the remarks made above on the late spawning of the John Dory here at the northern boundary of its spawning region, apply also to the boar-fish.

Pl. I, fig. 5 **Length: 15¼ mm.** The body is very high and compressed (maximum height 7 mm. and distance from the snout to the caudal fin 11½ mm.) and in this regard resembles *Zeus faber* most of all the post-larvæ known to me. The form of the fish is almost rhomboidal, and its uppermost point (at the beginning of D^1) and its lowest point (at the base of the ventral fins) are almost in a vertical line. *Capros* differs from the *Zeus* larvæ, as in many other ways, mainly in having a much longer snout (in *Zeus* the angle of the snout was greater than 90°, here it is considerable less than 90°). From the shape of this also we have the English (and Latin) name: boar-fish (aper). The distance from the tip of the snout to the anterior border of the eye is a little greater than the diameter of the eye. The longitudinal axis of the fish passes through the centre of the eye, whereas in *Zeus* the latter lies above the longitudinal axis. What is extremely characteristic is that almost the whole of the body is densely beset with small spines, densest and largest on the periphery.

The present stage has in the main the same form as the old fish, and all the rays in the fins (with exception perhaps of the pectorals) are already present. The tip of the notochord is quite reduced. The caudal fin is broad posteriorly, almost fan-like, with nearly straight upper and lower margins and evenly convex posterior margin. It contains 15 (16) rays beset with weak, widely separated spinous protuberances. These are also present on the soft rayed portion of the dorsal and anal fins (which contain respectively 24 and 23 rays), chiefly only on the proximal part of the rays. The spinous rayed portion of D contains 9 rays beset with strong spines and the spinous portion of the anal fin 3 very powerful, knife-like rays without spines. The interspinous bones of the dorsal and anal fins are beset with strong spines. The ventral fins are long and reach backward almost to the middle of the anal fin. They contain 6 rays, the first 3 of which are the longest and, especially the first, beset with extremely powerful, short, compressed spines which in their form resemble those of a rose.

The lateral aspects of the body are densely covered by stellate chromatophores, though not so densely as in the postlarval fry of the John Dory, and the head and postorbital region have likewise but little or no pigment. Of the fins the caudal and the soft-rayed portion of the dorsal and anal are without pigment, but on the other hand the pigmentation on D^1 and the ventrals is fairly strong.

Verification of the determinations

The following numbers are given in the ichthyological hand-books of F. Day[1], Moreau[2] and Lilljeborg[3] for *Zeus faber* and *Capros aper*.

***Zeus faber* L.**

	D^1	D^2	C	A^1	A^2	V	Vertebræ
Day	10	22—23	13	4	21—23	1/6	32 (14 + 18)
Moreau	9—10	22—23	15	3—4	21—22	1/5	
Lilljeborg	10	22—24	13	4	20—23	1/7	

Capros aper

	D^1	D^2	C	A^1	A^2	V	Vertebræ
Day	9	23—25	«	3	23—24	1/5	22—23 (10 + 12—13)
Moreau	9—10	23—24	3 + 12 + 3	3	23	1/5	

[1] F. Day: The Fishes of Great Britain and Ireland, vol. I, p. 134 og p. 139, 1881.
[2] E. Moreau: Poissons de la France, vol. II, p. 175 og p. 167.
[3] W. Lilljeborg: Sveriges och Norges Fiskar, vol. I, p. 285, 1891.

The determination of the described series of postlarval stages of *Zeus faber* has not presented any great difficulty. In spite of their small size these young fishes are already remarkable for their very considerable body-height, a characteristic which makes it impossible to think of any but a very few genera and amongst these, owing to the form and position of the fins, only of the genera *Zeus* and *Capros*.

From the numbers of rays given on p. 5 for the oldest postlarval specimen of 19 mm. we see that they quite correspond to those quoted here for *Zeus faber*. Further, I have counted the vertebræ in a specimen of about 9 mm. (quite identical with that represented in fig. 2) and found that it had in all 33 vertebræ, 16 abdominal and 17 caudal, and thus belonged to *Zeus faber* as *Capros aper* according to the above list has only ca. 22—23 vertebræ. The specimens figured (figs. 1—4) also approach much nearer to *Zeus* in the blunt form of the snout than the sharp-snouted *Capros aper*.

That the specimen described p. 6 and represented in fig. 5 really belongs to the latter species appears, apart from what has been said above, from its great resemblance to the adult *Capros aper* in the whole form of the body and snout (cf. e. g. the figure in Day, vol. I, Pl. XLVII). In the postlarval specimen figured the following number of rays were found: D^1: 9, D^2: 24, C: 15, A: 3 + 23, V: 6, thus quite the same numbers as those given above for *Capros aper*. I have not counted the vertebræ in this specimen, as the correctness of the determination according to the above characteristics (and after the vertebræ in a specimen belonging to the developmental series of the Dory had been counted) was quite beyond doubt and because I should have damaged my only specimen. (In order to count the vertebræ in postlarvæ so densely pigmented as these it is often necessary not only to clear in xylol or the like but to remove the skin to get them sufficiently transparent.)

B. THE COMMON POGGE (*AGONUS CATAPHRACTUS*) AND THE ARCTIC POGGE (*AGONUS DECAGONUS*)

1. The Arctic Pogge (*Agonus decagonus* Bloch, Schneider)

Whilst the young stages of this arctic species have been mentioned and described by various Scandinavian authors (Krøyer, Steenstrup, Lütken, Collett, Smitt), this is not the case with the pelagic, postlarval stages. During our investigations with the "Thor" at Iceland in 1903—05, when the species was found to be common in somewhat deep water on the east and north coast, I have also taken its early pelagic stages down to a length of quite 10 mm. and from these I shall give here a description of the postlarval developmental history, which in many ways differs greatly from that of the common pogge (*Agonus cataphractus*).

Description of the developmental history

Length: 12 mm. The form is exceedingly elongated, much more so than in specimens of *Agon. cataphractus* of the same size, which are also then much further forward in development. Whilst the length is 12 mm., the greatest height (halfway between the snout and the anus) is only 1·2 mm. and the height of the body a little behind the anus is even only ca. $^2/_3$ mm. Pl. I, fig. 6

The form of the head presents no special characteristic and the mouth is almost horizontal. The eyes are nearly circular and very large, ca. $^2/_3$ mm. in diameter or more than double the distance from the tip of the snout to their anterior margin. The distance from the snout to the anus (preanal length) is ca. 5 mm. The body is surrounded by an extremely high embryonic fin, exceeding the body in height.

A little behind the anus we thus find the height of the body and embryonic fin together to be 2·3 mm., to which the body only supplies $^2/_3$rds of a mm. The embryonic fin is very thick and has a finely reticulated structure. It shows no depressions whatsoever which might indicate the formation and position of the unpaired fins.

The tip of the notochord is practically straight, but indications of the interspinous bones can be seen below as a low triangular fold and ca. 7 faint traces of hypural rays can also be detected, though they are still very short and far from reaching out to the margin of the embryonic fin. In this further the very first, extremely faint indications of the rays in D^2 and A can be noticed; but these are still so very faint that they can hardly be figured. Ventrals are still lacking, but the pectorals are extremely large and broad lobes (ca. 2 mm.) provided with traces of rays. They reach backwards more than half the distance from their base to the anus and, as the figure shows, they are considerably broader (higher) than the body.

Pigment. There is some diffuse pigment on the postoccipital region and the under jaw and its base are likewise pigmented. Ventrally the preanal pigment is present as a distinct median row of small dots extending almost from the base of the pectorals posteriorly to near the anus. The abdominal pigment (on the intestinal tract) is well-developed. This applies also to the postanal pigment. This consists of 3 transverse bars as in so many other postlarvæ. The posterior bar (no. 1) lies near the end of the notochord, the anterior (no. 3) a little behind the anus and the middle one (no. 2), which is considerably longer than no. 3, almost about midway between the other two. The pigment of these transverse bars extends out on to the embryonic fin; at no. 1 it is strongest below along the developing rays; opposite no. 2, close up to the contour of the body on the embryomic fin and especially ventrally, there is a low streak of pigment; but especially opposite no. 3 there is a very well-marked, short pigmented area ventrally on the embryonic fin, which is almost quadrangular in shape. In the last case there is also a little pigment dorsally on the embryonic fin near to the contour of the body. As can be seen however from the figure, the pigment on the body is not quite sharply limited to the transverse bars; there is also a little pigment outside these. Some fine dashes of pigment are present on the large fan-like pectoral fins.

What has been said applies to the black pigment which is present on the preserved specimens (in formalin). I may add the following note on the pigment in the living specimens, written in my Journal for June 27th 1903 on board the "Thor" at North Iceland. "*Agonus decagonus*: the postlarval stages are easily distinguished from those of *Agon. cataphractus* by having narrow, well-marked sulphur-yellow streaks (dorsally two, the posterior the longest; ventrally two) along the margin of the embryonic fin opposite the black bars of pigment".

Pl. I, fig. 7 **Length: 14·6 mm.** The form is essentially the same as in the preceding stage. The preanal length is 6·8 mm. Faint signs are now present of the later, so characteristic spiny processes on the postoccipital region. The end of the notochord is very strong and still but very little bent. There are ca. 10—11 developing rays in the caudal fin below, but they do not yet reach out to the margin of the embryonic fin. The latter is still very broad and shows as yet no depressions or hollows to mark off the later unpaired fins. About 7 traces of rays are present in the region of the anal fin, the anterior, nearest the anus being very faint. There are also ca. 7 indications of rays in the region of the 2nd dorsal, which, however, are not yet very distinct. The 1st dorsal is not yet marked off. In the large, fan-like pectoral there are ca. 12 developing rays, but not all of them are distinct.

The pigment is in the main as before, but denser and more developed. In the interspaces between bars 1 and 2 as between 2 and 3 there is now so much pigment, that the bar-arrangement could only with difficulty have been distinguished in this specimen, if it had not been made out from examination of other, smaller and larger specimens.

Length 16½ mm. The form is essentially the same as before, but the whole volume has considerably increased. The preanal length is 7½ mm. The developing spines on the postoccipital region are now more distinct. The head is flattened and the length of the snout, i. e. the distance from the tip of the snout to the anterior border of the eye, is considerably greater than in previous stages. Pl. I, fig. 8

The end of the notochord is considerably more curved than in previous specimens, but it is still strong. In the caudal fin below there are 12 developing rays which now reach out almost to the margin of the embryonic fin. The latter is still extremely broad, but a fold in it now indicates the position of the 2nd dorsal and the anal fins. In the 2nd dorsal there are ca. 8 developing rays which are fairly distinct and in the anal fin ca. 8, but the rays do not yet reach out to the margin of the embryonic fin in any of the fins. The pectorals are still very large and fan-like; they extend backwards relatively nearer the anus than in earlier stages but do not yet reach this. The ventrals appear as low protuberances a little behind the base of the pectorals.

The pigment is in the main as before; the medio-ventral pigment row in front of the anus is here specially distinct.

Length 18½ mm. The preanal length is ca. 7½ mm. Developing spines are present above on the postoccipital region and the anterior portion of the dorsum, decreasing in strength backwards. The head is broad and flattened with almost horizontal gape and distinctly flattened snout. The length of the snout is almost equal to the horizontal diameter of the eye. The latter is not circular. Pl. I, fig. 9

The end of the notochord is somewhat reduced and strongly bent upwards. There are 11—12 rays in the caudal fin which almost reach out to the margin of the embryonic fin. In the 2nd dorsal and anal fins there are 8 rays, the anterior of which are the strongest. The 1st dorsal has now begun to form far forward in the embryonic fin which is there much lower than posteriorly. There are 5 quite short, faint, developing rays, which are separated from D^2 by a long interspace (in contrast to *A. cataphractus*). All the fin-rays are now present in the unpaired fins, but the embryonic fin is still exceedingly broad, for example between the caudal fin and D^2 and A where it disappears later, of which there is at present no sign.

The pectorals now reach back almost to the anus. The ventrals which are placed between the bases of the pectorals are still quite short. The pigment shows no essential changes.

Length 27½ mm. The preanal length is now only 11 mm., which indicates that the position of the anus has already been pushed considerably forward in the direction of the place it occupies in the adult fish. The head is very flattened and broad (resembling not a little the head of an alligator in form), whilst the body, especially the postanal portion, is compressed. The spines which are characteristic of the adult individuals of this species (*Agonus spinosissimus* Gthr.) have already appeared along the whole of the body. Pl. I, fig. 10

The end of the notochord is reduced and bent upwards. The caudal fin contains 12 rays, springing from the almost vertical posterior margin of the caudal peduncle. The 2nd dorsal and the anal each contain 12 rays and the still low 1st dorsal, which is placed far from the 2nd (in contrast to the condition in *Agonus cataphractus*), ca. 5 rays. The anal fin begins a good way behind the anus and some distance in front of the 2nd dorsal. Though the embryonic fin is relatively lower than in the previous stage it has not yet disappeared and still connects all the unpaired fins. The pectorals are extremely large and broad lobes containing 12 rays; they reach posteriorly behind the anus. The thread-like ventrals, which lie under (between) the bases of the pectorals, have developed considerably since the last stage, but do not yet reach halfway to the anus.

The pigment is in the main not changed, and the 3 original transverse bars can still be easily distinguished. The basal parts of the unpaired fins are beset with pigment points, which also cover the large fan-like pectorals. For some reason or another the pigment otherwise was much faded in this specimen.

The last developmental stage of *A. decagonus* described already resembles the adult specimens of this species so much that there is no reason to describe and figure still older stages.

2. The Common Pogge (*Agonus cataphractus* L.)

The developmental history of this species is so well known through the investigations of Mc Intosh, Mc Intosh & Prince and Ehrenbaum[1] that I do not require to describe it in detail. I shall merely limit myself to a brief statement of some of the characters, which distinguish this species from its arctic ally *Agonus decagonus*.

A specimen of *Agonus cataphractus*, 7 mm. in length, taken on the south coast of Iceland is represented in fig. 11 of the Plate. We see that it is much shorter and plumper in form than the corresponding stage of *A. decagonus* (fig. 6). With regard to the postanal pigment, we find here again the same type as in *A. decagonus*: 3 transverse bars, as can be seen from the figure; but there is this difference that the bars in *A. cataphractus* only appear on the embryonic fin, not on the body itself where they are fused together, whilst in *A. decagonus* they are also easily recognisable on the body.

Fig. 12 represents a second specimen of *Agonus cataphractus* from South Iceland, $10^1/_2$ mm. in length. In this the fins are already developed as also the spinous armour. The arrangement of the postanal pigment in 3 bars can still be recognised, as will be seen from the figure. This stage of only $10^1/_2$ mm. in length is almost as far on in development as the largest specimen figured of *A. decagonus* which was $27^1/_2$ mm. long. In this condition we have on the whole a main difference between the two species (cf. also the specimen of *A. cataphractus* of 7 mm. represented in fig. 11 which in development corresponds almost to the *A. decagonus* of 12 mm. represented in fig. 6), which means that a postlarval specimen of *A. cataphractus* is much further on in development than an *A. decagonus* of the same size. This condition is probably connected with the fact that whilst *A. cataphractus* belongs to warm, quite shallow water, *A. decagonus* is an arctic species occurring in deeper water. We find similar conditions at least in other fishes, namely, that the postlarval stages of arctic species are much further back in development than specimens of the same size of nearly related species with more southerly distribution, i. e. spawning in warmer waters (cf. for example, the arctic halibut, *Hippoglossus hippoglossoides* and the polar cod *Gadus saïda*, with the related species[2]).

Verification of the determinations

The following number of fin-rays etc. are given in the ichthyological hand-books of Day[3], Lilljeborg[4], Collett[5] and Smitt[6]:

[1] cf. Ehrenbaum, Wissensch. Untersuchungen, Abt. Helgoland, Bd. VI, p. 141—145, where the earlier literature is given.

[2] cf. Johs. Schmidt: On pelagic postlarval halibut (*Hippoglossus vulgaris* Hem. and *Hippoglossus hippoglossoides*); Meddel. Kom. Havunders. Serie Fiskeri, Bind I, No. 3, 1904 and

idem: The pelagic postlarval stages of the Atlantic Species of Gadus; Part I, p. 26, ibid. No. 4, 1905.

[3] F. Day: The Fishes of Great Britain and Ireland vol. I, p. 68, 1881.

[4] R. Collet: Norges Fiske, Christiania 1875, p. 40 og 42.

[5] W. Lilljeborg: Sveriges och Norges Fiskar, vol. I, p. 187 og 193, 1891.

[6] F. A. Smitt: Skandinaviens Fiskar vol. I, p. 206 ff., Stockholm 1892.

***Agonus cataphractus* (L.)**

	D¹	D²	C	A	V	Vertebræ
Day	5	5—6	12	6	1 + 2	36 (11 + 25)
Lilljeborg	5—6	6—8	7	5—7	1 + 2	
Collett	5—6	6—7	»	6	»	
Smitt	5—6	6—8	x + 7 + x	6—7	1 + 2	

***Agonus decagonus* Bloch, Schneider**

	D¹	D²	C	A	V	Vertebræ
Lilljeborg	5—7	5—8	9	6—8	1 + 2	
Collett	5—6	7	12	7—8	3	
Smitt	7	6—8	x + 7 + x	7—8	1 + 2	

It will be seen from this summary that the number of fin-rays is not suited to a certain distinction of the two species. The number of vertebræ is better, *Agonus cataphractus* having as shown above 36. Regarding the number in *A. decagonus* I have not found anything in the literature, but the vertebræ in 4 older specimens taken by the "Thor" at East Iceland have been counted by Cand. mag. Strubberg and in all the number was found to be 45[1], thus considerably more than in *A. cataphractus*.

That the developmental series described above belonged to an *Agonus* species was determined by the whole form and course of the developmental history, by the form and position of the fins, and by the form and spines on the head. As the series of stages was distinctly different from that of *Agonus cataphractus* there could only be talk of *A. decagonus*, which further according to our investigations is common at N. and E. Iceland, and with this agreed the greater slenderness of the specimens, the spiny formations, the great distance between the two dorsal fins etc. Though superfluous I counted the vertebræ in a postlarval specimen after clearing in xylol and found ca. 45, thus the same number as was found in the adult specimens of this species.

Remarks on the occurrence of the two species of Pogge within the regions investigated by the "Thor"

The trawling experiments of the "Thor" as well as the fishing with pelagic apparatus round Iceland showed that whilst *Agonus cataphractus* was common in quite shallow water (ca. 10—20 meters or more), both on the south and west coasts (warm water), *Agonus decagonus* was not found there. On the other hand the latter is common in deeper water (e. g. 100—175 M.) on the east and north coasts[2] (cold water).

Like so many other nearly related species *A. cataphractus* and *decagonus* are vicarious in their geographical distribution at Iceland; the former is a shallow and warm water form, the other a deep and cold water form, and the two species mutually exclude one another, so to speak, owing to their different requirements as to depth and temperature. In agreement with this also is the fact, that *Agonus cataphractus* occurs much further to the south (Great Britain, North Sea, Danish waters) than *A. decagonus*, which occurs in great quantities for example at Spitzbergen and in other arctic waters.

It is not only however in their geographical (horizontal) distribution that *A. cataphractus* and

[1] It is difficult to determine the limit between the abdominal and caudal vertebræ; but there are probably 13 abdominal and 32 caudal (A. Strubberg).

[2] In the deep Reydar Fjord on the east coast I have for example often taken it in quantity with a Norwegian shrimp-trawl used in fishing for *Pandalus borealis*. Thus on Aug. 10th 1904 a haul of 2 hours at a depth of 162 meters (65°00′ N., 13°49′ W.) gave 41 specimens of *Agonus decagonus* of the following length:

6	8	10	12	14	16	18	20 cm.
7 3	2 4	6 2		2 6	2 2	2 2	1 specimens.

A. decagonus are vicarious species, but also in regard to their vertical distribution. This is seen with great clearness, for example, in the deep fjords of East Iceland, e. g. Reydar Fjord, where the bottom water is very cold, ca. 1°—2°, whilst the water near the surface at any rate in summer is warmed up very considerably, to ca. 6°—8° or perhaps even more. I may thus mention two bottom hauls made there on July 31st 1903. The first of these made from $2^1/_2$ fathoms to the shore gave the common pogge (*Agonus cataphractus*), but the other at a depth of ca. 70 fathoms the arctic pogge (*Agonus decagonus*). Thus both species occurred in the fjord, but vicarious in regard to vertical distribution, as outer conditions corresponding to their requirements were present in the same fjord owing to the prevailing, peculiar hydrographical conditions.

EXPLANATION OF PLATE

Fig. 1. *Zeus faber*; **Length: $7^3/_4$ mm.** "Thor", Stat. 165, Aug. 24th 1906; 49° 49′ N, 6° 20′ W (W. part of the Channel), depth: 72 meters. Young-fish trawl, 140 meters wire out.

Fig. 2. *Zeus faber*; **Length: $8^1/_3$ mm.** "Thor", Stat. 199, Sept. 15th 1906; 50° 57′ N, 1°05′ E (E. part of the Channel), depth: 34 meters. Young-fish trawl 25 meters wire out.

Fig. 3. *Zeus faber*; **Length: $10^1/_2$ mm.** "Thor", Stat. 194, Sept. 12th 1906; 47° 42′ N, 5° 30′ W, (off Brittany); depth: 130 meters. Young-fish trawl, 65 meters wire out.

Fig. 4. *Zeus faber*; **Length: 19 mm.** "Thor", Stat. 164, Aug. 23rd 1906; 50° 14′ N, 4° 24′ W (Channel); depth: 60 meters. Young-fish trawl, 25 meters wire out.

Fig. 5. *Capros aper*; **Length: $15^1/_4$ mm.** "Thor", Stat. 196, Sept. 14th 1906; 49° 24′ N, 3° 21′ W (Channel); depth: 76 meters. Young-fish trawl, 65 meters wire out.

Fig. 6. *Agonus decagonus*; **Length: 12 mm.** "Thor", Stat. 151, July 2nd 1903; 66° 17′ N, 21° 14′ W (North Iceland); depth: 180 meters. Young-fish trawl, near the surface (10 meters wire out).

Fig. 7. *Agonus decagonus*; **Length: 14·6 mm.** "Thor", Stat. 144, June 27th 1903; 3 miles N. N. E. of Flatey (North Iceland); depth: 40 meters. Young-fish trawl, near the surface (10 meters wire out).

Fig. 8. *Agonus decagonus*; **Length: $16^1/_2$ mm.** Same haul as Fig. 7.

Fig. 9. *Agonus decagonus*; **Length: $18^1/_2$ mm.** "Thor", Stat. 149, July 2nd 1903; 66° 17′ N, 18° 17′ W (North Iceland); depth: 115 meters. Young-fish trawl, near the surface (10 meters wire out).

Fig. 10. *Agonus decagonus*; **Length: $27^1/_2$ mm.** "Thor", Stat. 140, July 30th 1905; 66° 00′ N, 14° 30′ W (N. E. Iceland); depth: 72 meters. Young-fish trawl, 65 meters wire out.

Fig. 11. *Agonus cataphractus*; **Length: 7 mm.** "Thor", Stat. 43, April 27th 1904; 64° 29′ N, 14° 09′ W (South Iceland); depth: 74 meters. Young fish trawl, 70 meters wire out.

Fig. 12. *Agonus cataphractus*; **Length: $10^1/_2$ mm.** "Thor", Stat. 54, May 23rd 1905; 64° 02′ N, 15° 40′ W (South Iceland); depth: 71 meters. Young-fish trawl, 65 meters wire out.

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TOME II

CONTENTS

Page

Nr. 1. C. G. Joh. Petersen: ON THE LARVAL AND POST-LARVAL STAGES OF SOME *PLEURONECTIDÆ* (*PLEURONECTES, ZEUGOPTERUS*). (WITH 1 PLATE) ..... 1—10

Nr. 2. Johs. Schmidt: THE PELAGIC POST-LARVAL STAGES OF THE ATLANTIC SPECIES OF *GADUS*. A MONOGRAPH. PART II. (WITH 1 PLATE) 1 20

Nr. 3. Johs. Schmidt: ON THE PELAGIC POST-LARVAL STAGES OF THE LINGS (*MOLVA MOLVA* [LINNÉ] AND *MOLVA BYRKELANGE* [WALBAUM]). (WITH 1 PLATE AND 3 FIGURES IN THE TEXT) ..... 1—16

Nr. 4. Johs. Schmidt: ON THE LARVAL AND POST-LARVAL DEVELOPMEMT OF THE ARGENTINES (*ARGENTINA SILUS* [ASCAN.] AND *ARGENTINA SPHYRÆNA* LINNÉ). WITH SOME NOTES ON *MALLOTUS VILLOSUS* [O. F. MÜLLER]. (WITH 2 PLATES) ..... 1—20

Nr. 5. A. C. Johansen: CONTRIBUTIONS TO THE BIOLOGY OF THE PLAICE WITH SPECIAL REGARD TO THE DANISH PLAICE-FISHERY. II. THE MARKING AND TRANSPLANTATION EXPERIMENTS WITH PLAICE IN THE DANISH WATERS IN THE YEARS 1903—06. (CONTAINING 6 PLATES AND 10 TEXT-FIGURES) ..... 1—122

Nr. 6. Johs. Schmidt: MARKING EXPERIMENTS ON PLAICE AND COD IN ICELANDIC WATERS. (WITH 2 CHARTS) ..... 1—23

Nr. 7. Johs. Schmidt: ON THE POST-LARVAL DEVELOPMENT OF THE HAKE (*MERLUCCIUS VULGARIS* FLEM.). (WITH 1 PLATE AND 4 FIGURES IN THE TEXT) ..... 1—10

Nr. 8. Johs. Schmidt: ON THE POST-LARVAL DEVELOPMENT OF SOME NORTH ATLANTIC GADOIDS (*RANICEPS RANINUS* [LINNÉ] AND *MOLVA ELONGATA* [RISSO]). (WITH 1 PLATE AND 1 FIGURE IN THE TEXT) ..... 1—14

Nr. 9. Johs. Schmidt: ON THE POST-LARVAL STAGES OF THE JOHN DORY (*ZEUS FABER* L.) AND SOME OTHER ACANTHOPTERYGIAN FISHES. (WITH 1 PLATE) ..... 1—12

ERRATA

IMPORTANT CORRECTION

In Vol. II, No. 2 (The pelagic postlarval stages of the Atlantic species of *Gadus*, Part II, 1906) a serious printer's error which alters the meaning appears on pp 17—18.

What is found there on p. 18 above on *G. minutus* and *G. Esmarki* should really stand on p. 17, following immediately after *G. merlangus*, as the two former like the latter species belong to Main Group II (as stated l. c., p. 4 above), and not to Main Group III as would appear to be the case from their position on p. 18.

In the same way, what is written on *G. minutus* and *G. Esmarki* p. 19 should stand on p. 18 immediately after what is said about *G merlangus*.

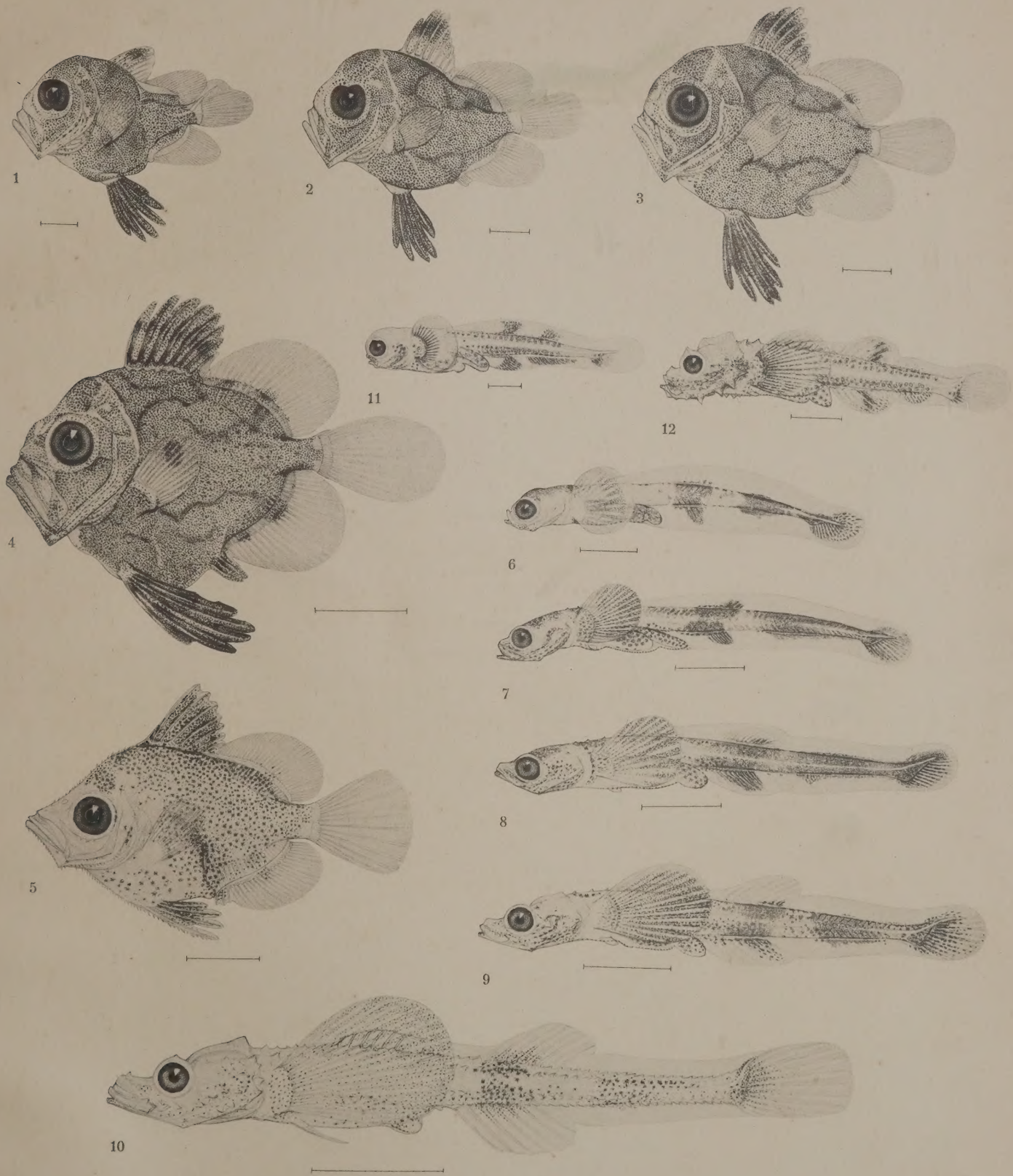

Fig. 1—4. *Zeus faber.* Fig. 5. *Capros aper.* Fig. 6—10. *Agonus decagonus.* Fig. 11—12. *Agonus cataphractus.*